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Segment No. 05-10-02

WA-10-0010

METALS CONCENTRATIONS IN ASARCO DISCHARGES AND RECEIVING WATERS FOLLOWING PLANT CLOSURE

by

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October 1987

ABSTRACT

Discharges and receiving waters at and adjacent to the ASARCO facility on Commencement Bay were analyzed for trace metals to determine if ongoing discharges from the facility are elevating metals concentrations in nearshore waters. Concentrations of most metals in ASARCO outfalls were generally lower than when the plant was operating and in the range of values reported by ASARCO since the plant closed. In addition, the total metals load (arsenic, cadmium, copper, lead, and zinc combined) discharged from the plant site has decreased by more than two orders of magnitude since operations ceased. Slight impact was observed in the receiving waters, however, no clear violations of EPA criteria for the protection of saltwater aquatic life were observed. Based on the available data, mean concentrations of arsenic, cadmium, lead, and nickel were generally in the range of values typical for Puget Sound.

INTRODUCTION

The ASARCO copper smelter and refinery has long been a source of metals to Commencement Bay, having started operations in 1890. Prior to closing, average estimated loads of arsenic (480 lbs/day), cadmium (11 lbs/day), copper (150 lbs/day), lead (14 lbs/day), and zinc (120 lbs/day) resulted in a combined estimated load of 780 lbs/day to Commencement Bay via three NPDES outfalls. Sediments below these outfalls were found to contain sufficient levels of arsenic, antimony, cadmium, copper, lead, mercury, nickel, and zinc to be considered toxic to marine life (Tetra Tech, 1985).

The last operations at ASARCO closed in early 1986. Discharges are now limited primarily to storm water runoff and, perhaps, ground water percolation through the site. The slag pile at the northwest end of the facility, may also leach metals to the bay. It is not known what impact these discharges may have on the marine environment. The objective of this investigation was to determine if ongoing discharges from ASARCO are elevating metals concentrations in nearshore waters.

METHODS

Sampling Plan

A reconnaissance survey was conducted September 9, 1986, to select sampling sites (Figure 1). Five potential surface discharges the North, Middle, and South Outfalls (formerly NPDES permitted discharges) and two storm drains which border the facility (the North Boundary Storm Drain which serves Ruston, and the Edwards Street Storm Drain which collects runoff from a residential area above the ASARCO facility) were also identified. Receiving water stations (surface and bottom waters) were located near each above discharge, adjacent to the slag pile, and at one site offshore.

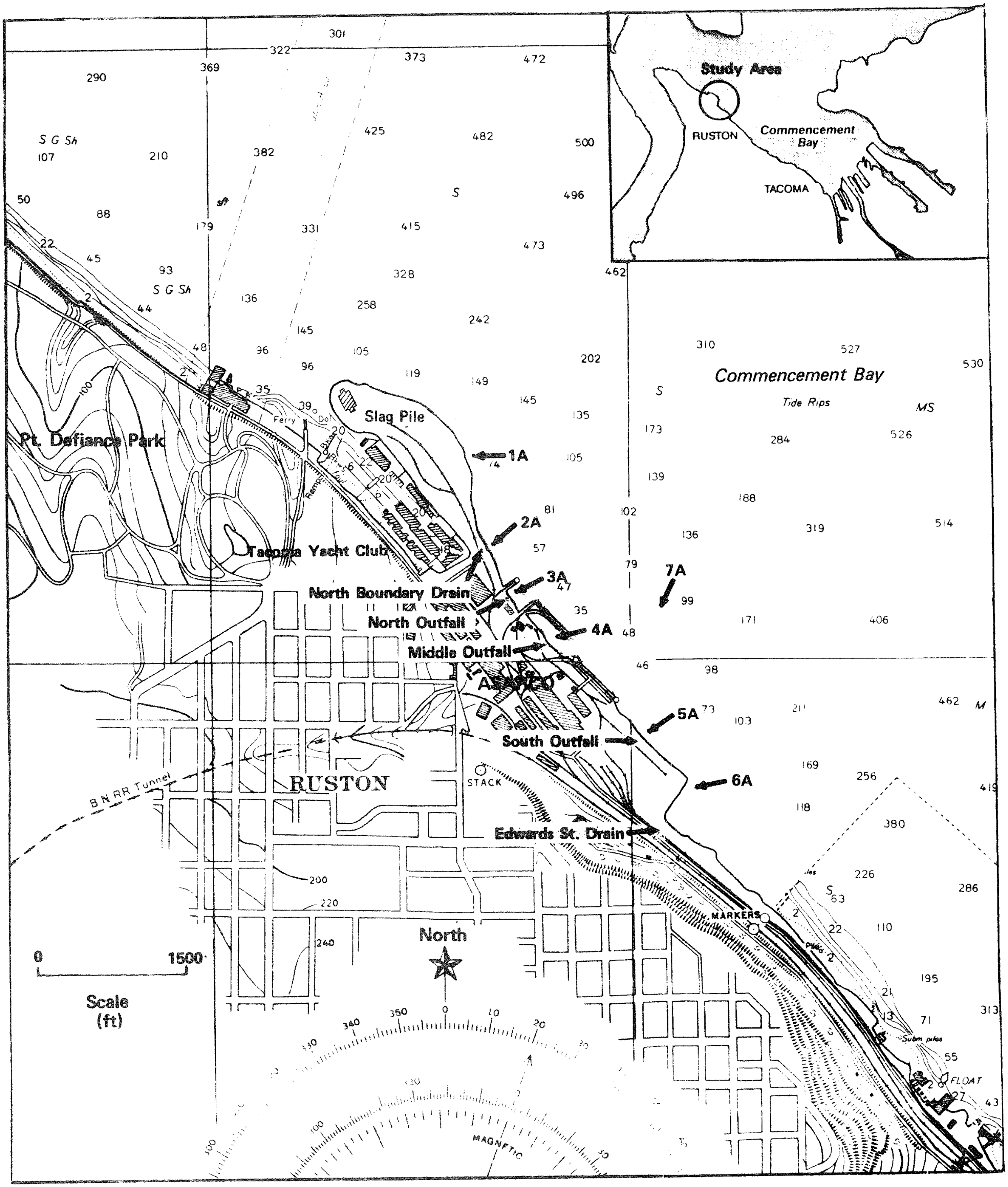

Figure 1: Locations of samples collected by Ecology at the ASARCO facility.
(Descriptions of these locations are also provided in Appendix I)

Dry- and wet-weather surveys were conducted to assess seasonal variations in metals concentrations. The dry-weather survey took place October 21, 1986. The only discharge flowing was the Middle ASARCO Outfall. The wet-weather survey occurred November 19, 1986. At that time all discharges except the North ASARCO Outfall and the North Boundary Storm Drain were flowing. Rainfall for the week preceding each survey is listed in Table 1.

Table 1. Precipitation recorded at the 26th and Pearl rain gauge for the week preceding each ASARCO survey (data obtained from Ray Redding, Tacoma Public Works Department, Sewer Utility Division).

Date	Precipitation (Inches)	Date	Precipitation (Inches)
10/14/86	0	11/12/86	0
10/15/86	0	11/13/86	0.2
10/16/86	0	11/14/86	0.05
10/17/86	0	11/15/86	0
10/18/86	0	11/16/86	0.1
10/19/86	0	11/17/86	0
10/20/86	0	11/18/86	0.65
10/21/86*	0	11/19/86*	0.2

* = Date of sample collection

Receiving water sampling was performed during a period of minimum tidal exchange (i.e., neap tides) within two hours following high slack water. This is when maximum receiving water impacts were expected.

Sample Collection

Discharge samples were collected as grabs in one-gallon priority pollutant-cleaned glass jars with Teflon-lined screw closures (I-Chem, Hayward, California). All samples were collected from mixing boxes at the point of discharge.

Receiving water surface samples were taken as grabs from a depth of 0.5 feet. Bottom samples were collected in an acid-cleaned, ten-liter, Teflon-lined General Oceanics Go-Flo bottle, deployed on Phillystran Kevlar/polyester rope. Bottom samples were taken approximately ten feet above the bottom.

Aliquots for metals analyses were transferred to acid-cleaned, one-quart, Nalgene bottles provided by Battelle Marine Research Laboratory, Sequim, Washington. Separate aliquots were taken for total and dissolved metals analyses. Samples for total metals analysis were preserved at the time of collection by adding 1 mL hydrochloric acid (Baker Instra-Analyzed for Trace Metals Analysis). Aliquots for mercury analysis were placed in borosilicate glass bottles and preserved with 2 mL nitric acid. One-quart Nalgene bottles were used for pH, specific conductance, total suspended solids (TSS), and salinity samples.

Aliquots for dissolved metals determinations were filtered through 0.4 micron Nucleopore polycarbonate filters which had been pre-cleaned by soaking for one week in 50 percent nitric acid and then rinsed in distilled-deionized water. Filtering occurred within ten hours of sample collection. After filtration, these samples were also preserved with 1 mL hydrochloric acid.

All samples were kept on ice in the field and transported to the Ecology/EPA Environmental Laboratory at Manchester, Washington, the day after collection. Samples were held at 4°C until analyzed.

Flow was measured with a bucket and stop-watch at the South ASARCO Outfall. Flow for the Middle ASARCO Outfall was calculated from head measurements at the 90° V-notch weir. No direct flow data were available for the Edwards Street Storm Drain.

Laboratory Analyses

Metals analyses other than mercury were done by the Battelle Sequim Laboratory. Arsenic and antimony were analyzed by hydride generation with a quartz burner atomic absorption spectrophotometry (AAS) detector (Bertine and Lee, 1983; Crecelius, 1978). Cadmium, copper, lead, and nickel were pre-concentrated from seawater by APDC co-precipitation before analysis using AAS with a Zeeman graphite furnace (Bloom and Crecelius, 1984). Zinc was analyzed by direct injection along with a matrix modifier. Mercury analysis was done at the Manchester Laboratory using cold vapor method 245.2 (EPA, 1979).

pH, specific conductance, TSS, and salinity were analyzed at the Manchester laboratory. pH was measured with a Corning 155 pH meter. Specific conductance was measured using a Beckman RC20 conductivity meter. Analysis for TSS followed method 160.2 (EPA, 1979). Salinity was determined using an American Optical refractometer, with results checked by the argentometric method specified in <u>Standard Methods for the Examination of Water and Wastewater</u> (APHA, 1985).

Quality Assurance

This investigation followed the procedures and guidelines specified in Tetra Tech (1986) <u>Quality Assurance Project Plan for Field Investigations to Support Commencement Bay Nearshore/Tideflats Feasibility Study</u>.

QA review of the metals data was done by Deborah Coffey, of Tetra Tech, Inc., Bellevue, Washington. The data were concluded to be of known and documented quality in terms of accuracy, precision, spike recoveries, and detection limits for all metals except antimony.

Accuracy and precision of the antimony data were considered suspect; these data are therefore qualified throughout this report (Tetra Tech, 1987).

National Research Council of Canada (NRCC) standard seawater reference materials were analyzed by Battelle to assess the accuracy and precision of the metals measurements. Battelle results, shown in Table 2, were in excellent agreement with NRCC certified values. Poor agreement was seen for antimony, however, the NRCC antimony value is not certified.

Table 2. Results of Battelle analyses of National Research Council of Canada standard seawater reference materials.

Reference Material	Metal	Certified Value (ug/L)	Battelle Value (ug/L)
NASS-1	Arsenic	1.65 ± 0.19	1.55 ± 0.09 sd (n=7)
NASS-1	Antimony	0.21*	1.55 ± 0.09 sd (n=7)
CASS-1	Cadmium	0.026 ± 0.005	0.026 ± 0.001 sd (n=5)
SLRS-1	"	0.015 ± 0.002	0.015 ± 27 rpd (n=2)
CASS-1	Copper	0.291 ± 0.027	0.31 ± 0.019 sd (n=5)
SLRS-1	"	3.58 ± 0.30	3.58 ± 12 rpd (n=2)
CASS-1	Lead	0.251 ± 0.027	0.23 (n=1)
CASS-1	Nickel	0.290 ± 0.031	0.30 (n=1)
SLRS-1	"	1.07 ± 0.06	1.11 ± 0.06 sd (n=6)
CASS-1	Zinc	0.980 ± 0.099	1.01 ± 0.10 sd (n=7)

mean ± sd = standard deviation or; rpd = relative percent difference of duplicates
NASS = Seawater reference material for trace metals
CASS = Nearshore seawater reference material for trace metals
SLRS = Riverine water reference material for trace metals
* = Not certified

Battelle has previously analyzed blanks for containers used in this study. Consistently low metals concentrations were measured, indicating the containers were not a source of contamination (Crecelius, 1987). The effects of filtration on metals concentrations were evaluated by filtering Manchester blank water. Concentrations of all metals except nickel and zinc were at or near detection limits in both unfiltered (total metals) and filtered (dissolved metals) blank water (Appendix II). Similar levels of contamination were present in both types of blanks for nickel, which suggests that the Manchester water was initially contaminated with this metal. This was als case for zinc during the November 19 collection; however, during the October 21 survey a much higher concentration of zinc was seen in the filtration blank. Based on blank results no alterations to the data were deemed necessary except for dissolved zinc. Dissolved zinc values appear to be elevated at lower concentrations by field filtration and therefore are not reported for receiving water samples. All metals data reported here have been corrected for method blanks.

RESULTS

Total Metals in Discharges

The results of analysis of samples collected from ASARCO outfalls and an adjacent storm drain are in Table 3.

During dry weather, only the Middle Outfall was flowing. This discharge had a relatively small flow (0.10 MGD), low suspended solids content, and high concentrations of all metals except mercury, which was not detected.

Under wet-weather conditions, the Middle and South Outfalls and the Edwards Street Storm Drain were flowing. Again, relatively small flows (Middle Outfall, 0.10 MGD; South Outfall, 0.013 MGD) and generally high metals concentrations were seen in ASARCO's discharges. Mercury was also detected at 0.06 ug/L in both outfalls. Substantial metals concentrations were also present in the Edwards Street Storm Drain. However, with the exception of lead, concentrations were generally lower than in the two ASARCO outfalls, especially for arsenic, cadmium, and zinc. The Edwards Street Drain had the highest lead concentration (270 ug/L) measured in any discharge. The highest concentrations of arsenic (690 ug/L); cadmium (56 ug/L); copper (1,100 ug/L); nickel (34 ug/L); and zinc (1,900 ug/L) were found in the Middle Outfall during dry weather. No substantial differences were seen in metals concentrations in the Middle Outfall between dry- and wet weather with the exception of zinc, which was approximately 50 percent lower during wet weather.

Total metals loads from the two ASARCO outfalls are shown in Table 4. Combined metals loads for each outfall were as follows; Middle Outfall (dry), 3.3 lbs/day; Middle Outfall (wet), 2.0 lbs/day; and South Outfall, 0.13 lbs/day. As previously mentioned, no direct flow data were available for the Edwards Street Storm Drain; however, an estimated maximum flow of 22 MGD based on pipe dimensions and slope was provided by Tim Sparling of the Tacoma Public Works Department, Sewer Utility Division. Based on this information, the potential exists that this drain could be a major metals source.

Total Metals in Receiving Waters

Table 5 summarizes the results of analyses of receiving water samples (complete data set is in Appendix II and III).

Table 3. Summary of analyses of samples collected from outfalls at the ASARCO facility and the Edwards Street Storm Drain, October 21 and November 19, 1986.

Sample Number	Sample Location	Flow (MGD)	pH	Spec. Cond. (umhos/cm)	Total Susp. Solids (mg/L)	Total Metals (ug/L) Arsenic	Antimony*	Cadmium	Copper	Lead	Mercury	Nickel	Zinc
DRY WEATHER+													
43-8210	Middle ASARCO Outfall	0.10	7.5	305	<1	690	60*	56	1,100	45	0.09u	34	1,900
WET WEATHER++													
47-8275/82	Middle ASARCO Outfall	0.10	7.6	249	6.7	480	50*	34	940	27	0.06	22	860
47-8270	South ASARCO Outfall	0.013	7.7	4,630	4.3	310	210*	6.6	360	34	0.06	7.9	220
47-8265	Edwards Street Storm Drain	--	6.7	52	51	85	70*	2.9	300	270	0.06u	9.2	100

u = Not detected at the detection limit shown
* = Accuracy and precision of data suspect
\+ = October 21, 1986
++ = November 19,1986
-- + No data

Table 4. Metals loads (total metal) to Commencement Bay from outfalls at the ASARCO facility (values reported in lbs/day).

	Dry Weather	Wet Weather	
Location	Middle Outfall	Middle Outfall	South Outfall
Sample Number	43-8210	47-8275/82	47-8270
Sample Date	10/21/86	11/19/86	11/19/86
Flow (MGD)	0.10	0.10	0.013
Arsenic	0.58	0.40	0.034
Antimony*	0.050*	0.042*	0.023*
Cadmium	0.047	0.028	0.00072
Copper	0.92	0.78	0.039
Lead	0.038	0.023	0.0037
Mercury	--	0.00005	0.0000065
Nickel	0.028	0.018	0.00086
Zinc	1.6	0.72	0.024
Total Load	3.3	2.0	0.13

-- = Not detected
 * = Accuracy and precision of data suspect

Table 5. Summary of analysis of ASARCO receiving water samples collected October 21 and November 19, 1986.

Location	pH (S.U.)	TSS (mg/L)	Salinity (ppt)	Metals (ug/L) Arsenic	Antimony*	Cadmium	Copper	Lead	Mercury	Nickel	Zinc
-Dry Weather+											
Nearshore[1]											
surface (n=6)	7.8(7.8)	<1(<1)	29(28-29)	1.6(1.2-2.4)	1.5(1.2-1.9)*	.13(.10-.15)	.75(.37-1.7)	.03(.01-.06)	.09u(.09u)	.53(.51-.55)	8.0(2.4-18)
bottom (n=6)	7.8(7.8-7.9)	<1(<1)	29(28-29)	1.8(1.3-3.3)	1.6(.98-2.1)*	.11(.074-.15)	.85(.29-1.7)	.17(.03-.45)	.09u(.09u)	.55(.43-.65)	5.0(.94-9.0)
Offshore[2]											
surface (n=1)	7.9	<1	29	.86	1.6*	.10	.50	.02	.09u	.56	3.5
bottom (n=1)	7.9	<1	28	1.3	1.1*	.13	.49	.04	.09u	.51	1.7
-Wet Weather++											
Nearshore											
surface (n=6)	7.8(7.7-7.9)	3(<1-10)	30(29-30)	1.8(1.1-2.2)	1.1(.65-1.5)*	.10(.091-.12)	1.1(.26-1.7)	.18(.01-.35)	.06u(.06u-.12)	.60(.45-.71)	21(1.7-51)
bottom (n=6)	7.8(7.8)	2(<1-2)	30(29-30)	1.7(1.3-2.1)	1.0(.67-1.7)*	.10(.084-.12)	.67(.43-1.0)	.08(.04-.14)	.06(.06u-.06)	.59(.57-.64)	7.3(.94-20)
Offshore											
surface (n=1)	7.8	<1	30	1.6	.65*	.10	.51	.05	.06u	.54	7.9
bottom (n=1)	7.8	2	30	1.5	1.4*	.11	.44	.03	.06u	.59	7.9

n = number of samples
mean(range)
u = not detected at detection limit shown
* = Accuracy and precision of data suspect
+ = October 21, 1986
++ = November 19, 1986
1 = Station numbers 1A, 2A, 3A, 4A, 5A, and 6A
2 = Station number 7A

In general, the receiving waters had low concentrations of all metals except zinc. Based on mean values, slightly higher concentrations of copper, lead, and zinc were seen in nearshore versus offshore waters. No substantial differences were noted in metals concentrations between dry- and wet weather or surface and bottom samples, except for zinc and mercury which were somewhat elevated in nearshore surface waters during wet weather. The highest zinc (51 ug/L) and mercury (0.12 ug/L) concentrations detected were near the Middle Outfall.

Dissolved Metals

The percentage of total metals concentrations in dissolved (i.e. less than 0.4 um) form are shown in Table 6. In ASARCO discharges most metals were in the dissolved form. Exceptions to this pattern were copper (17 percent dissolved) during dry weather and lead (2 to 9 percent dissolved) during dry- and wet-weather conditions in the Middle Outfall, and lead (5 percent dissolved) in the South Outfall. In the receiving waters all metals were primarily in the dissolved form.

In some instances dissolved metals concentrations exceeded total metals concentrations. However, substantial differences occurred only in the case of lead.

DISCUSSION

Table 7 compares metals concentrations measured in outfalls from the ASARCO facility before and after plant shutdown. Concentrations of arsenic, copper, lead, and nickel in the Middle Outfall and arsenic, cadmium, lead and nickel in the South Outfall are generally lower than when the facility was operating. Antimony in the South Outfall is still in the range of operational concentrations. However, as previously mentioned, the accuracy and precision of Ecology's antimony data are suspect.

Concentrations of arsenic, cadmium, copper, lead, and zinc measured in the present study (Middle and South Outfalls only) are within the range of values reported by ASARCO since the plant closed (Ecology, 1987). More importantly, comparing the average estimated total load of 780 lbs/day when the plant was operating, the current combined load of approximately 2 to 3 lbs/day represents more than a two-orders-of-magnitude decrease in loading.

To place receiving water results from this investigation into perspective, representative metals concentrations reported for Puget Sound waters by a number of investigators are summarized in Table 8. In general, based on mean values, the available data indicate that arsenic, cadmium, lead, and nickel concentrations measured by Ecology near the ASARCO facility fall into the range of values seen in other parts of Puget Sound. Current zinc concentrations are similar to those reported near ASARCO while the plant was operating. Mercury concentrations approximately one order of magnitude higher than typical for

Table 6. Percentage of metals in dissolved form in ASARCO outfalls, Edwards Street storm drain and surface receiving waters.

Location		Metals					
		Arsenic	Antimony*	Cadmium	Copper	Lead	Nickel
-Dry Weather-							
Discharge							
Middle Outfall	(n=1)	78	64*	64	17	2	61
Receiving Water							
Nearshore	(n=7)	97(78-123)	73(47-90)*	92(77-110)	110(59-130)	240(40-700)**	120(95-140)
Offshore	(n=1)	140	74*	94	110	130	110
-Wet Weather-							
Discharge							
Middle Outfall	(n=2)	64(60-67)	120(97-140)*	110(92-120)	65(58-72)	6(3-9)	98(96-100)
South Outfall	(n=1)	76	70*	120	66	5	120
Edwards St. Drain	(n=1)	69	13*	75	75	28	49
Receiving Water							
Nearshore	(n=8)	91(68-120)	120(72-200)*	93(82-110)	97(68-200)	85(13-500)**	110(80-130)
Offshore	(n=1)	82	190*	130	86	140	120

n = Number of samples
mean(range)
* = Accuracy and precision of data suspect
** = Concentration range: Dry; total = (0.01-0.06), dissolved = (0.02-0.08)
Wet; total = (0.01-0.35), dissolved = (0.02-0.11)

Table 7. Metals concentrations in ASARCO outfalls before and after plant shutdown.

	Metals (ug/L)						
Discharge	Arsenic	Antimony	Cadmium	Copper	Lead	Nickel	Zinc
South Outfall							
Prior to 1986*	260-80000	160-1100	30-1700	860-15500	20-2300	170-240	1300-3500
DMR data 4/86 to 3/87	70-6700	83u-270	2u-730	33-17000	17-400	--	17-12000
Present Study	310	210**	6.6	360	34	7.9	220
Middle Outfall							
Prior to 1986*	2700-18500	62-140	50-170	2100-8700	200-880	300-400	1400-2800
DMR data 4/86 to 3/87	160-5700	--	12-110	330-1800	17-150	--	33-3600
Present Study	480-690	50-60**	34-56	940-1100	27-45	22-34	860-1900
North Outfall							
Prior to 1986*	42-150	22-100	5u-10	50-700	61-130	8-400	10-160
DMR data 4/86 to 3/87	20-1700	--	2u-120	88-1600	10u-350	--	17-1200

* = Data on discharges prior to 1986 summarized from Tetra Tech (1985).
DMR = Discharge Monitoring Reports; from Ecology SW Regional Office files.
u = Not detected at detection limit shown
-- = Not analyzed
** = Accuracy and precision of data suspect

Table 8. Summary of historical and present study data on metals concentrations in ASARCO receiving waters, Commencement Bay, and the main Puget Sound Basin.

	Metals (ug/L)						
Location	Arsenic	Cadmium	Copper	Lead	Mercury	Nickel	Zinc
ASARCO Receiving Water							
Total							
Roesijadi (1982)	--	0.11-6.7	3.02-105	--	0.0023-0.019	--	9.5-110
Gurtisen (1982)	--	--	0.4-7.0	--	--	--	--
Carpenter, et al. (1978)	1.76-2.56	--	--	--	--		
Present Study	0.86-3.3	0.074-0.15	0.26-1.7	0.01-0.45	0.06u-0.12	0.43-0.71	0.94-51
Dissolved							
Paulson & Feely (1985)	--	0.080-0.097	0.24-1.1	0.07-0.11	--	0.28-0.34	0.26-2.4
Present Study	1.0-2.2	0.084-0.14	0.44-1.7	0.02-0.11	--	0.52-0.86	--
Commencement Bay							
Total							
Dissolved							
Paulson & Feely (1985)	--	0.070-0.089	0.24-0.50	0.03-0.09	--	0.23-0.35	0.27-0.65
Puget Sound Main Basin							
Total							
Bloom & Crecelius (1983)	--	--	--	--	0.00016-0.0007	--	--
Carpenter, et al. (1978)	1.5-2.0	--	--	--	--	--	--
Crecelius (1975)	1.51	--	--	--	--	--	--
Schell & Barnes (1974)	--	--	--	0.7-5.4	0.0016	--	--
Dissolved							
Paulson & Feeley (1985)	--	0.062-0.14	0.20-0.48	0.03-0.08	--	0.25-0.42	0.14-0.60

-- = Not analyzed
u = Not detected at detection limit shown

Puget Sound were also measured by the Manchester Laboratory, however, most were at the analytical detection limit of 0.06 ug/L. Uncertainty associated with measurements at quantitation limits can be ± 50 percent (Twiss, 1987). It is therefore difficult to determine if these concentrations represent actual environmental conditions.

EPA water quality criteria for the protection of saltwater aquatic life are listed in Table 9. No violations of these criteria were observed in ASARCO receiving waters except for mercury during wet weather, which exceeded the chronic criteria of 0.025 ug/L. However, as noted above there is some uncertainty about the accuracy of these measurements.

Table 9. Water quality criteria for the protection of saltwater aquatic life (EPA, 1986; 1987).

Metal	Acute (ug/L)	Chronic (ug/L)
Arsenic	2319	--
Antimony	--	--
Cadmium	43	9.3
Copper	2.9	--
Lead	140	5.6
Mercury	2.1	0.025
Nickel	75	8.3
Zinc	95	86

-- = Saltwater criteria not established.

SUMMARY

The major findings of this investigation are as follows;

- The highest concentrations of arsenic (690 ug/L), cadmium (56 ug/L), copper (1100 ug/L), nickel (34 ug/L), and zinc (1900 ug/L) measured in ASARCO discharges were in the Middle Outfall under dry-weather conditions.

- Concentrations of arsenic, copper, lead, and nickel in the Middle Outfall and arsenic, cadmium, lead, and nickel in the South Outfall are generally lower than when the plant was operating. In addition, arsenic, cadmium, copper, lead, and zinc in both outfalls are within the range of values reported by ASARCO since the plant closed.

- Similar metals concentrations were noted in the Middle Outfall between dry- and wet weather with the exception of zinc which was approximately 50 percent lower in wet weather.

- The current discharge of approximately 2 to 3 lbs/day from the ASARCO facility for arsenic, cadmium, copper, lead, and zinc combined represents more than a two-orders-of-magnitude loading decrease since plant operations have ceased.

- Slight impact was observed in nearshore receiving waters; however, no clear violations of EPA water quality criteria for the protection of saltwater aquatic life were noted with the exception of mercury, which exceeded the chronic criteria of 0.025 ug/L during wet weather. Due to uncertainty associated with the mercury analyses, additional sampling would be required to confirm this conclusion.

- Based on means, receiving water concentrations of arsenic, cadmium, lead, and nickel fall approximately into the range of values typically reported in other studies of Puget Sound. Current zinc concentrations are similar to levels reported near ASARCO while the plant was operating.

- In both discharges and receiving waters most metals were present in the dissolved form.

CONCLUSIONS

Based on the results of this investigation, it appears that ongoing discharges from the ASARCO facility are having little impact on metals levels in nearshore receiving waters even though relatively high concentrations of arsenic, antimony, cadmium, copper, lead, nickel, and zinc are still present in outfalls from the facility. There are some indications that mercury concentrations in nearshore receiving waters during wet weather are violating EPA water quality chronic criteria for the protection of saltwater aquatic life. However, additional data are required to confirm this conclusion.

RECOMMENDATIONS

In light of the results of this investigation, the following recommendations are made:

- Additional nearshore receiving water samples should be collected during wet weather and analyzed for mercury utilizing detection limits in the 1 ng/L range to determine if water quality violations are occurring.

- Metals loading from the Edwards Street Storm Drain should be assessed.

- Since limited receiving water impacts were noted in this study, further work at the ASARCO facility should concentrate on defining the extent and significance of metals contamination of bottom sediments.

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Appendix I. Station descriptions for Ecology surveys at ASARCO, October 21 and November 19, 1986.

Station Number	Site Description	T.P.C.H.D.* Drain No.	Lat./Long. (47/122)
Discharge			
2	North Boundary Storm Drain. Parallels chain link fence at north ASARCO boundary; manhole about 40 feet landward from shore	2	---
3	North ASARCO Outfall. NPDES permitted; sampled at mixing box	3	---
4	Middle ASARCO Outfall. NPDES permitted; sampled at mixing box	4	---
5	South ASARCO Outfall. NPDES permitted; sampled at mixing box	5	---
6	Edwards Street Storm Drain. Sample collected from manhole in south-bound lane of Ruston Way near concrete manhole structure	8	---
Receiving Water			
1A	Adjacent to slag pile 100 feet from north dolphin; 60 feet off shore	---	18'22"/30'23"
2A	North Boundary Storm Drain 50 feet off shore from outfall	---	18'11"/30'17"
3A	North ASARCO Outfall 60 feet from outfall mixing box; between piers	---	18'07"/30'15"
4A	Middle ASARCO Outfall 40 feet off shore from mixing box, south side of barge inside pier	---	18'03"/30'11"
5A	South ASARCO Outfall 50 feet off shore from outfall	---	17'53"/29'57"
6A	Edwards Street Storm Drain 600 feet off shore from concrete manhole structure on Ruston Way	---	17'48"/29'50"
7A	Off Shore about 1200 feet from central pier	---	18'05"/29'54"

*Tacoma Pierce County Health Department

Appendix II: Ecology data from ASARCO surveys of October 21 and November 19, 1986.

Sample Number	Sample Location		pH (s.u.)	Specific Conductance (umhos/cm)	Total Suspended Solids (mg/L)	Salinity (ppt)	Metals (ug/l)							
							Arsenic	Antimony	Cadmium	Copper	Lead	Mercury	Nickel	Zinc
						Dry Weather *								
43-8202	Edwards St. SD - Surface	T	7.8	-	<1	28	1.15	1.90	0.146	0.61	0.06	0.09u	0.54	3.61
43-8203	" " " "	D	-	-	-	-	1.49	0.90	0.140	0.56	0.03	-	0.86	11.8
43-8204	Edwards St. SD - Bottom	T	7.8	-	<1	29	1.40	2.12	0.150	0.29	0.07	0.09u	0.43	0.94
43-8207	S. ASARCO Outfall - Surface	T	7.8	-	<1	29	1.53	1.55	0.10	0.69	0.05	0.09u	0.55	2.07
43-8208	" " " "	D	-	-	-	-	1.56	1.37	0.110	0.64	0.02	-	0.56	4.28
43-8209	S. ASARCO Outfall - Bottom	T	7.8	-	<1	29	3.28	2.04	0.110	1.73	0.45	0.09u	0.54	2.54
43-8210	Middle ASARCO Outfall	T	7.5	305	<1	-	687	59.2	55.6	1,140	44.6	0.09u	34.2	1,870
43-8211	" " "	D	-	-	-	-	533	37.8	35.8	197	0.67	-	20.7	1,290
43-8212	Middle ASARCO Outfall - Surface	T	7.8	-	<1	29	2.44	1.35	0.116	1.67	0.03	0.09u	0.55	13.0
43-8213	" " " "	D	-	-	-	-	2.18	1.08	0.115	0.99	0.08	-	0.52	5.35
43-8214	Middle ASARCO Outfall - Bottom	T	7.8	-	<1	29	1.61	0.98	0.074	0.91	0.13	0.09u	0.65	1.34
43-8219	N. ASARCO Outfall - Surface (Dup 1)	T	7.8	-	<1	29	1.59	1.22	0.121	0.59	0.03	0.09u	0.51	17.0
43-8220	" " " " "	D	-	-	-	-	1.63	1.10	0.101	0.74	0.02	-	0.54	18.3
43-8221	N. ASARCO Outfall - Surface (Dup 2)	T	7.8	-	<1	29	1.61	1.37	0.137	0.59	0.02	0.09u	0.50	18.2
43-8222	" " " " "	D	-	-	-	-	1.32	0.94	0.106	0.75	0.07	-	0.56	1.20
43-8225	N. ASARCO Outfall - Bottom	T	7.9	-	<1	29	1.63	1.10	0.105	0.87	0.10	0.09u	0.57	8.96
43-8228	N. Boundary SD - Surface	T	7.8	-	<1	29	1.70	1.18	0.146	0.37	0.01	0.09u	0.52	2.4
43-8229	" " " "	D	-	-	-	-	1.39	0.88	0.117	0.45	0.07	-	0.57	0.53
43-8230	N. Boundary SD - Bottom	T	7.8	-	<1	29	1.41	2.04	0.133	0.87	0.26	0.09u	0.54	11.1
43-8231	Outside Yacht Basin - Surface	T	7.8	-	<1	28	1.26	1.84	0.124	0.56	0.01	0.09u	0.53	8.69
43-8232	" " " "	D	-	-	-	-	1.32	1.10	0.120	0.65	0.02	-	0.76	10.4
43-8233	Outside Yacht Basin - Bottom	T	7.8	-	<1	28	1.53	1.03	0.109	0.44	0.03	0.09u	0.54	5.08
43-8234	OffShore - Surface	T	7.9	-	<1	29	0.86	1.55	0.104	0.50	0.02	0.09u	0.56	3.48
43-8238	" " "	D	-	-	-	-	1.43	1.14	0.098	0.55	0.03	-	0.60	6.95
43-8235	OffShore - Bottom	T	7.9	-	<1	28	1.32	1.08	0.130	0.49	0.04	0.09u	0.51	1.74
43-8236	Transport Blank	T	-	-	-	-	0.02u	0.10	0.001u	0.13u	0.01	0.09u	0.02u	0.45u
43-8237	Filter Blank	D	-	-	-	-	0.02u	0.09u	0.003	0.13u	0.01	-	0.07	15.5

*= October 21, 1986
-=Not analyzed
Dup=Duplicate sample

T=Total metals concentrations
D=Dissolved metals concentrations
u=Not detected at detection limit shown

Appendix II: Continued.

Sample Number	Sample Location		pH (s.u.)	Specific Conductance (umhos/cm)	Total Suspended Solids (mg/1)	Salinity (ppt)	Metals (ug/1) Arsenic	Antimony	Cadmium	Copper	Lead	Mercury	Nickel	Zinc
							Wet Weather **							
47-8265	Edwards Street Storm Drain	T	6.7	52	51	1	84.7	70.4	2.91	297	268	0.06u	9.16	100
47-8266	" " " "	D	-	-	-	-	58.4	9.49	2.18	222	75.6	-	4.47	79
47-8267	Edwards St. SD - Surface	T	7.7	-	3.3	29	2.00	1.27	0.108	1.00	0.35	0.06u	0.63	22.7
47-8268	" " " "	D	-	-	-	-	1.36	1.35	0.104	0.80	0.08	-	0.67	29.0
47-8269	Edwards St. SD - Bottom	T	7.8	-	2	30	1.44	1.01	0.106	0.49	0.07	0.06u	0.58	7.22
47-8270	S. ASARCO Outfall	T	7.7	4,630	4.3	-	313	208	6.60	360	34.0	0.06	7.94	220
47-8271	" " "	D	-	-	-	-	238	145	8.01	237	1.75	-	9.16	270
47-8272	S. ASARCO Outfall - Surface	T	7.8	-	1.3	30	2.17	1.51	0.095	1.58	0.14	0.06u	0.58	16.0
47-8273	" " " "	D	-	-	-	-	1.99	1.16	0.084	1.08	0.04	-	0.71	40.0
47-8274	S. ASARCO Outfall - Bottom	T	7.8	-	2	29	1.91	0.86	0.084	1.03	0.10	0.06	0.60	1.87
47-8275	Middle ASARCO Outfall (Dup 1)	T	7.5	251	5.7	-	485	32.2	34.0	942	28.0	0.06	21.5	860
47-8276	" " " "	D	-	-	-	-	324	43.9	31.4	547	0.77	-	22.0	860
47-8282	Middle ASARCO Outfall (Dup 2)	T	7.6	246	7.7	-	464	63.3	34.1	932	26.4	0.06	22.4	860
47-8283	" " " "	D	-	-	-	-	278	61.2	39.6	667	2.35	-	21.5	850
47-8277	Middle ASARCO Outfall - Surface (Trip 1)	T	7.8	-	1.3	29	2.24	1.46	0.102	1.65	0.19	0.06u	0.61	44.0
47-8278	" " " " "	D	-	-	-	-	1.82	1.06	0.084	1.71	0.04	-	0.79	40.0
47-8302	Middle ASARCO Outfall - Surface (Trip 2)	T	7.9	-	2	30	2.36	1.47	0.116	1.66	0.32	0.06u	0.60	60.0
47-8303	" " " " "	D	-	-	-	-	1.99	1.06	0.095	1.39	0.08	-	0.63	15.2
47-8304	Middle ASARCO Outfall - Surface (Trip 3)	T	7.9	-	10	30	1.99	1.33	0.095	1.74	0.14	0.12	0.67	50.0
47-8305	" " " " "	D	-	-	-	-	2.07	1.41	0.095	1.15	0.02	-	0.59	3.48
47-8279	Middle ASARCO Outfall - Bottom	T	7.8	-	2	30	2.07	0.82	0.095	0.94	0.14	0.06	0.59	19.9
47-8286	N. ASARCO Outfall - Surface	T	7.8	-	<1	29	1.65	1.29	0.104	1.38	0.21	0.06	0.61	22.3
47-8287	" " " "	D	-	-	-	-	1.73	1.69	0.118	1.30	0.11	-	0.63	28.3
47-8288	N. ASARCO Outfall - Bottom	T	7.8	-	2.3	30	1.66	1.65	0.105	0.66	0.07	0.06u	0.57	3.88
47-8299	N. Boundary SD - Surface	T	7.8	-	<1	29	1.46	0.65	0.116	0.57	0.16	0.06u	0.71	14.4
47-8300	" " " "	D	-	-	-	-	1.02	1.27	0.087	0.47	0.02	-	0.57	1.20
47-8301	N. Boundary SD - Bottom	T	7.8	-	2.3	29	1.28	0.67	0.084	0.43	0.04	0.06u	0.64	9.89
47-8289	Outside Yacht Basin - Surface	T	7.8	-	1.3	30	1.13	0.69	0.091	0.26	0.01	0.06u	0.45	1.74
47-8290	" " " "	D	-	-	-	-	1.37	1.12	0.101	0.51	0.05	-	0.58	23.0
47-8291	Outside Yacht Basin - Bottom	T	7.8	-	<1	30	1.56	1.22	0.124	0.47	0.05	0.06	0.57	0.94
47-8292	OffShore - Surface	T	7.8	-	<1	30	1.56	0.65	0.104	0.51	0.05	0.06u	0.54	7.89
47-8293	" " "	D	-	-	-	-	1.28	1.22	0.130	0.44	0.07	-	0.62	16.6
47-8294	OffShore - Bottom	T	7.8	-	1.7	30	1.49	1.41	0.114	0.44	0.03	0.06u	0.59	7.89
47-8295	Transport Blank	T	-	-	-	-	0.02u	0.09u	0.003	0.05	0.03	0.06u	0.22	22.9
47-8296	Filter Blank	D	-	-	-	-	0.02u	0.09u	0.003	0.13	0.03	-	0.48	23.4

**=November 19, 1986
-=Not analyzed
Dup=Duplicate sample
Trip=Triplicate sample

T=Total metals concentrations
D=Dissolved metals concentratons
u=Not detected at detection limit shown

Appendix III. Field measurements for ASARCO receiving water surveys conducted by Ecology October 21 and November 19, 1986.

Station Number	Site Description	Time 10/21	Time 11/19	Bottom depth (ft) 10/21	Bottom depth (ft) 11/19	Sample Depth (ft) 10/21	Sample Depth (ft) 11/19	Water Temperature (C) 10/21	Water Temperature (C) 11/19	Salinity (ppt) 10/21	Salinity (ppt) 11/19
1	Outside Yacht Basin	0940	0910	62	60	surface*	surface	11.0	10.1	30.03	30.42
	Receiving Water	0935	0900			52	50	11.0	10.2	30.54	30.52
2A	North Boundary Storm Drain	1010	0940	38	38	surface	surface	11.0	10.0	30.50	30.05
	Receiving Water	1000	0940			28	28	11.0	10.1	30.16	27.15
3A	North ASARCO Outfall	1030	0950	42	42	surface	surface	11.0	10.1	30.22	30.56
	Receiving Water	1020	0950			32	32	11.0	10.1	30.25	30.52
4	Middle ASARCO Outfall	1425	1315	-	-	-	-	-	-	-	-
4A	Middle ASARCO Outfall	1055	1020	36	42	surface	surface	11.0	10.1	30.25	30.35
	Receiving Water	1045	1015			26	32	10.9	10.1	28.10	30.45
5	South ASARCO Outfall	a	1240	-	-	-	-	-	-	-	-
5A	South ASARCO Outfall	1115	1045	40	48	surface	surface	11.0	10.1	29.85	30.25
	Receiving Water	1110	1045			30	38	10.9	10.1	30.40	30.20
6	Edwards Street Storm Drain	a	1405	-	-	-	-	-	-	-	-
6A	Edwards Street Storm Drain	1135	1100	40	40	surface	surface	11.0	9.9	30.00	30.15
	Receiving Water	1130	1100			30	30	11.0	10.2	30.40	30.20
7	Offshore	1150	1115	80	80	surface	surface	11.1	10.1	30.42	30.31
	Receiving Water	1145	1115			70	70	11.0	10.1	30.50	30.41

*=0.5 ft
a=Drain not running, no sample collected